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FY07 LDRD Final Report Development of Hot, LTE-tunable Radiation Sources for Material Science Studies

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FY07 LDRD Final Report
Development of Hot, LTE-tunable Radiation Sources for Material
Science Studies
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Abstract

A high temperature radiation source is needed for materials studies under extreme conditions planned for large laser facilities such as OMEGA and NIF. An appropriate source produces hot radiation, has an optically thin region in which the material to be studied is placed, and keeps the heated material in LTE. This LDRD used the thin back wall of a hot hohlraum as the radiation source. The source was used to radiatively heat a sample. The temperature of the sample was characterized with x-ray spectroscopy.

Summary

This report contains three papers and one presentation.

The development of the thin back wall of a hot hohlraum as a radiation source is described in the first paper, "Development of a thermal X-radiation source using "hot" hohlraums" (HEDP 3 (2007) 256). This paper compared measurements of the radiation drive from the thin back wall of the hot hohlraum with predictions from simulations. It also described the geometry for heating a sample with the radiation source.

A soft x-ray spectrometer was designed and fielded to measure the spectra of the heated sample. This variable-spaced grating ("VSG") spectrometer is coupled to an x-ray framing camera. This gives both time and space information as a function of time. Two VSGs were built: they can be used either with a 6x or 24x spatial magnification.

The spectroscopy of the sample is described in the presentation "Update on development of a thermal X-radiation source". The results show several disagreements with simulations.

It is important to compare predictions from the simulations with measurements to understand other (undesired) mechanisms which might affect the sample. The simulations predict a high electron temperature in the hot, highly non-local thermodynamic equilibrium (nLTE) plasma in the region where plasma stagnation occurs and in the region where the laser deposits its energy. The plasma conditions here affect the laser-plasma interactions, which can produce hot electrons or highly non-thermal x-radiation which might also heat the sample. An L-band spectrometer was built to deduce the electron temperature. X-ray spectroscopy of the 3->2 transitions of highly-

charged gold ions (“L-band”) can measure the average charge state (“ $\langle Z \rangle$ ”), which is used in radiative-collisional modeling to deduce T_e .

One section of the article “An Overview of EBIT Data Needed for Experiments on Laser-Produce Plasma” describes results from the L-band spectrometer which indicate a lower T_e than predicted. This article has been accepted for publication in The Canadian Journal of Physics.

The article “High-temperature plasma diagnostics based on L-shell Au spectra” describes a comparison between high resolution L-band spectra measured using LLNL's Super Electron Beam Ion Trap facility with several atomic structure collisional-radiative models. The EBIT spectra benchmark the models at low density. There is disagreement among the models at densities relevant to “hot hohlraums”. Thus, the measured $\langle Z \rangle$ at OMEGA could indicate a higher T_e than quoted in the “An Overview ...” paper. This paper is submitted to Physical Review E.